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Poster paper

Survey and alignment design for the Taiwan photon source

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Taiwan Photon Source is a new 3-GeV ring with characteristics of great brightness and small emittance, at present under construction at National Synchrotron Radiation Research Center (NSRRC) site in Taiwan and due to be commissioned in 2013. The positioning of the magnets is highly sensitive to alignment errors, and the entire building will be constructed half underground at depth 12 m relative to Taiwan Light Source (TLS) for stability reasons; for these reasons the survey and alignment work is confined and difficult. To position magnets precisely and quickly, a highly accurate auto-tuning girder system combined with a survey network was designed to accomplish the alignment tasks. The survey network includes a preliminary Global Positioning System (GPS) network and a laser-tracking network. The position data from the survey network define a basis for the system of motorized girders to auto-tune and improve the accuracy. The detailed survey and alignment design, simulation and preliminary data are described in this paper.

1. Introduction

Taiwan Photon Source (TPS) is a new 3-GeV ring under construction at the NSRRC site in Taiwan, with circumference 518.4 m and 24 double-bend cells. For stability reasons, the entire building is being constructed half underground at depth 12 m relative to TLS. To position magnets precisely and quickly, a highly accurate system of auto-tuning girders combined with survey network procedures was designed to accomplish the alignment tasks. The survey network includes the preliminary GPS network and a laser-tracker network. The network control points of TPS will be established with several survey instruments. The positions of girders will be measured and pre-aligned with a laser tracker; the position data then define a basis for the motorized girder system to improve the accuracy (Wang *et al.* 2008; Lai *et al.* 2009).

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2. Survey and alignment process

As the TPS building will be constructed half underground, the survey and alignment work will be confined and difficult. To ensure that the entire TPS building is located in its designed position, eight basic GPS control points on the roofs of the main buildings and ground link to the existing survey coordinate system as in figure 1(*a*). After the TPS building floor is grouted, 24 common fiducial points as in figure 1(*b*) will be established, and distributed in the store ring and the experimental hall. These points will serve not only to verify the tunnel walls but also as common survey points to combine survey network data of various instruments.

There are also 48 survey windows to combine the common fiducial points between the store ring and the experimental area. After construction of the building is completed, the tunnel network control points will be established by integrating a laser tracker and levelling as shown in figure 2. Of the four major alignment stages during installation, the first is that all pedestal templates and beam centrelines must be set by the laser tracker for the following civil engineering. Second, all pedestal and booster magnets must be aligned within 0.2 mm. Third, all girders with magnets will be put on the pedestals and aligned within 0.1 mm with the laser-tracker survey network. Finally, the positions of girders will be improved taking prior survey data for a base position into the auto-alignment program and adjusting with the system of motorized girders.

3. Alignment result of prototype

The prototype system forms one of 24 sections of the store ring to confirm that survey alignment and installation are completed without problem. The maximum adjustments of the six-axis adjusting system (Tseng *et al.* 2006) are designed to be 7.5, 3 and 5 mm in heave, sway and surge directions, respectively, as shown in figure 3(*a*). When girders are just placed on pedestals without adjustment, the maximum deviations of the girder position are 2.2, 0.9 and 0.5 mm in heave, sway and surge directions, respectively. The error arises from the alignment of pedestals, grouting and manufacturing, and error of the rotation angle of cam movers. These errors influence the adjusted value; another factor is the weight of magnets that induces the sinking and inclination of the girders. The sinking and inclination values are 0.5 mm and 0.14 mrad, respectively, caused from the 12-tonne magnet

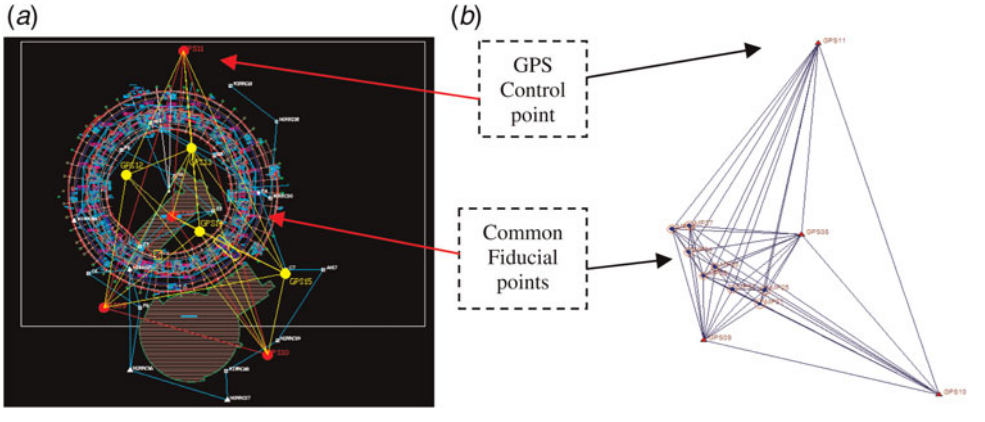

FIGURE 1. (*a*) Basic GPS network. (*b*) Common fiducial points.

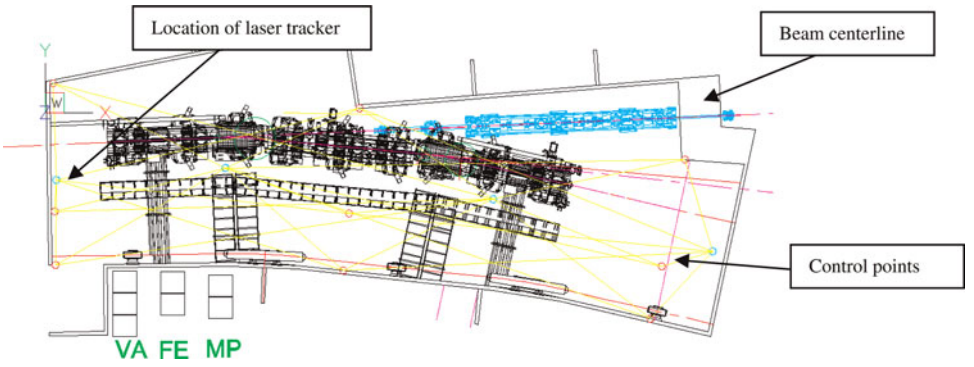

FIGURE 2. Tunnel control points.

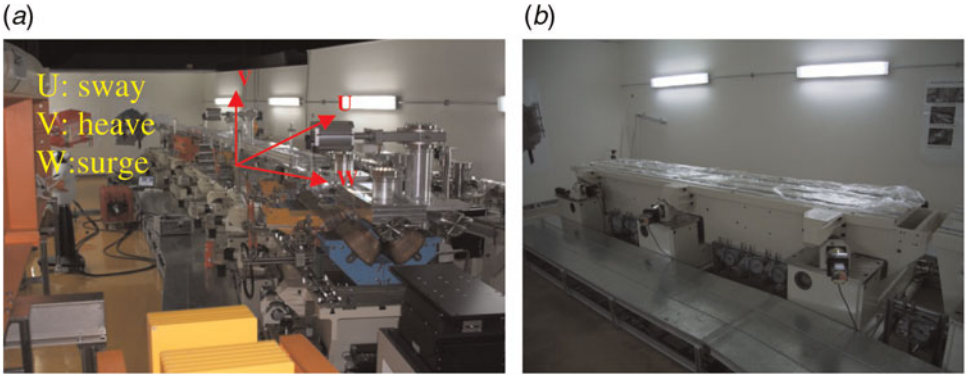

FIGURE 3. (*a*) Coordinates of the girder. (*b*) Installation of prototype.

being distributed unequally on a girder. Half-magnets were taken off after all girders were aligned to the design position within 0.1 mm by the laser tracker, and a 14-m vacuum system was installed on the design position as shown in figure 3(*b*). Finally, the magnets are replaced and the girders lay away from the original position by 0.1 mm. The adjustment takes account of the weight change, girder displacement and environment change.

4. Conclusion

To accomplish the stringent alignment tasks of the new TPS project, a survey network system combined with a system of highly accurate auto-tuning girders was designed, simulated and tested as a prototype. From testing of the 1/24 mock-up section on installation and the network simulation, this design shows promising results. The survey network is at present under construction, but the accuracy of the combined system requires further testing.

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